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Line and continuum spectra of H.F. at Alibag during quiet and disturbed periods

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The nature of spectral lines and continuum spectra in the wavelength range 5 min to 185 min has been investigated for two periods, one of relative magnetic calm and the other disturbed. Spectra of digitized (2.5 min) Horizontal Intensity at Alibag suggest that during disturbances significant fluctuations occur in the range of 37.0 min to 185.0 min. These are ascribed to the variation in the mean level of the solar wind. From the computed power law it is noticed that the functional dependence of the continuum power on the frequency is almost the same for quiet and disturbed periods. The level of the continuum, however, is about 5½ times higher during the disturbed period.

INTRODUCTION

In the course of a study of the magnetic data by spectrum analysis in the period range of 40 days to 5.5 years, Currie (1966) suggested that the continuum spectrum often provides information about the physical mechanisms that generate a time series. According to Banks (1969) continuum spectrum is generated by a real geophysical process and is not the result of instrumental noise or a function of the local observatory environment. To investigate the spectrum it is necessary to use sufficient length of data of any observatory. But the data are often vitiated by noise, such as, due to instrumental, scaling or reading errors or due to errors in copying, calculating, printing and rounding-off of the data.

The old and established observatory at Alibag (dip 24°.4N) has a collection of excellent magnetic data extending over several decades. The continuum spectra of horizontal intensity of the earth's magnetic field during a period of low solar activity have been computed from a selection of samples from this data for quiet and disturbed periods. As short period fluctuations are known to become prominent during disturbed conditions the present analysis has been made to cover the wavelengths from 5 min to 185 min. To facilitate comparison an analysis restricted to quiet day data, has also been done. The functional dependence of the power density of the null continuum over the frequency has been computed for quiet and disturbed periods.

For adequate resolution 2.5 min digitized data of Alibag, made available by World Data Centre, have been used. Two series, one each for quiet and disturbed periods have been considered. The data used for computations for quiet and disturbed periods have been confined to the same month and year so that the seasonal and solar cycle characteristics remain the same. Using Bartel's diagram three days from September 12 to September 14, 1964 were selected as a sample of a quiet period, the index A_p being 2 on each of those days. Three days, from September 7 to September 9, 1964 were selected as a sample of a disturbed period, the index A_p these days being 28, 23 and 16. Each series consisted of 1728 data points extending over a period of 72 hours. Following the procedure outlined by Blackman & Tukey (1959) autospectra were computed with a maximum lag of 300. Prior to computations a high pass digital filter was applied to each series to eliminate long period (diurnal and semi-diurnal) variations. Trend-free series, Y_t, were computed from the series of digitized data, X_t, by the linear transformation :

$$Y_t = \sum_{k=-n}^{n} W_k X_{t+k}$$

where W_k was the k-th weight of the filtering function and $n = 100$. The response of the filter was nearly unity for periods shorter than 187 minutes. Its response was zero for wave length of 625 minutes and above. From the autocorrelations computed in the course of power spectrum analysis the *noise* characteristic of the series was tested. The lag-one serial correlation coefficient r_1 differed significantly from zero and the relations $r_2 \simeq r_1^2$, $r_3 \simeq r_1^3$, etc, were satisfied where r_2 and r_3 were the serial correlation coefficients of lag 2 and lag 3. The null continuum was, thus, assumed as that of Markov *red noise*, as outlined in Tech. Note No. 79. Assuming that r_1 was an unbiased estimate of the spectrum, the null continuum was computed from the following relationship :

$$s_k = \bar{s}\left[\frac{1-r_1^2}{1+r_1^2-2r_1\cos\dfrac{\pi k}{m}}\right]$$

where $\bar{s}$ was the average of all raw spectral estimates, m = number of lags and $k = 0, 1, 2, \ldots, m$. 95 per cent confidence line of the continuum was computed for each spectrum with chi-square values corresponding to the number of degrees of freedom $(2N-M/2)/M$ where N was the number of data points and M was the maximum lag. The line spectra, null continua and 95 per cent confidence lines of the null continuum are shown in figures 1 & 2. As the continuum decreased asymptotically with increasing frequency, the power law for each series was determined by the relation $P = Af^{-\alpha}$ where P was the power density of the null continuum corresponding to the frequency f, α the functional dependence and A, a constant.

Results

From the spectral estimates of the data for the quiet period it is noticed that peaks significant at 95 per cent level occur at the periods of 34.1, 30.6, in the bandwidth of 26.8 and 25.9 min and at 18.3 min. The power density of the null continuum has a functional dependence $f^{-\alpha}$ on frequency where $\alpha = 1.65$ and constant $A_q = 0.12 \times 10^{-4}$. For the disturbed periods spectral peaks significant at 95 per cent confidence level occur in the wavelength from 166.7 to 150 min and

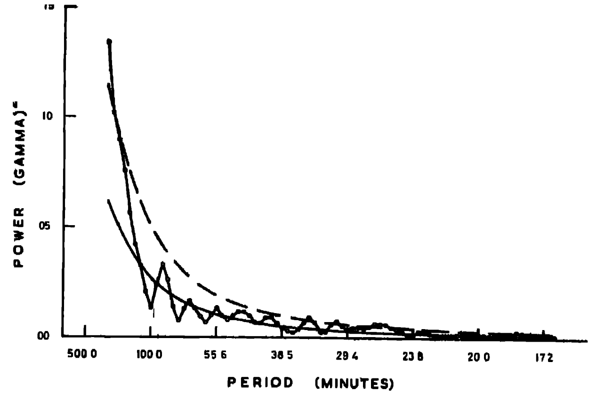

Figure 1. Spectra of Alibag H. F during Quiet period. The line, joining the circles represents the line spectrum. The continuous line is the null continuum and the broken line represents 95 percent confidence line of the null continuum.

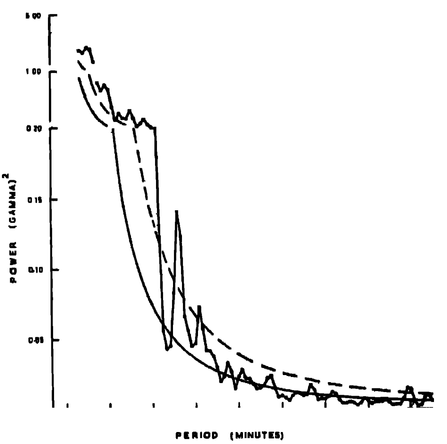

Figure 2. Spectra of Alibag H. F. during Disturbed period. The line joining the circles represents the line spectrum. The continuous line is the null continuum and the broken line represents 95 percent confidence line of the null continuum.

at wavelengths of 107.1, 83.3, 71.4, 60.0, 44.1, 37 5, 15.3 and around 11.0 min. The power density of the null continuum has a functional dependence $f^{-\alpha}$ on frequency where $\alpha = 1.72$ and constant $A_d = 0.66 \times 10^{-4}$.

Discussion

According to Parker (1967) the longer period fluctuations of the magnetic field are due to the variations in the mean level of the solar wind. From both the spectra it is observed that in the low frequency range the number of spectral peaks significant at 95 per cent confidence level are higher during disturbed period. This is to be expected because larger variations over mean level of the enhanced solar wind can be expected only during disturbances. From the investigation of periodic fluctuations in the geomagnetic field during 36 storms in 1958, Pai & Sarabhai (1964) observed that the most common periods were 40-50 min Some fluctuations had periods as large as 60 to 80 min. Best & Grafe (1969) from their studies of proton flare events between August 27 and September 7, 1966 suggested that for H and D components at Honolulu, the spectral density peaks occur around 100-120 min They also noticed spectral peaks at 50 to 60 min and 90 to 120 min at Niemegk and Sitka. Bhargava & Rao (1970) studied the fluctuations in the period range of 6-150 min for the statistical properties of world-wide fluctuations during disturbed periods at several stations and observed a peak around 120 min. They also obtained shorter period secondary oscillations with periods around 25 and 37 min. From this investigation it is noticed that significant spectral peaks also occur in the period range of 150 to 166.7 min and around 11 and 15 min. It is also noticed that, for both quiet and disturbed periods, the functional dependence of continuum power on frequency is almost same, being 1 65 and 1.72. These constants are slightly lower than the constant of about 2.0 obtained by Mason (1963) from his study on spectra for D, H and Z of 4 disturbed days of 3 stations for periods in the rage 6-120 min.

Although the functional dependence of power on frequency is almost equal in both the series, the level of the continuum during disturbed period is about $5\frac{1}{2}$ times higher than that of quiet period as noticed from the ratio of A_d to A_q. This may be ascribed to the intensification of solar wind during the disturbed period. Currie (1966) pointed out that at some observatories no semi-annual or annual lines were observed in the spectra and this indicated that Observatory noise was severe resulting in the continuum power levels being higher than the line spectra. From this study it is noticed that during disturbances the continuum level is slightly higher than the line spectrum towards the high frequency end of the spectrum (from 7.7 min to 5 min). This feature is, however, absent during quiet period. This result suggests that the contribution of the instrumental noise to the continuum is negligible. That the continuum level is higher than the line spectrum only during disturbed period could be ascribed to either noise during disturbances or rounding-off error of the data, a feature likely to be more effective during disturbed periods.

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